CLAIMS:

1. A beam-shaping optical element having an entrance surface, an exit surface located opposite thereto and an optical axis, wherein the optical axis coincides with the Z-axis of a three-axis rectangular XYZ system of coordinates, and at least one of the entrance surface and the exit surface is represented by a mathematical equation comprising a term representing a non-rotationally symmetric aspherical profileand correction terms, each correction term being a function of either variable X or Y, at least one of the correction terms being a function of variable X and at least one of the correction terms being a function of variable Y.

2. A beam-shaping optical element according to claim 1, wherein the at least one correction term comprising a function of variable X alone comprises a power of X, multiplied by a correction factor and the at least one correction term comprising a function of variable Y alone comprises a power of Y, multiplied by a correction factor.

3. A beam-shaping optical element according to claim 1, wherein the at least one of the entrance surface and the exit surface is represented by the mathematical equation

$$Z = \frac{c_x x^2 + c_y y^2}{1 + \sqrt{1 - (1 + k_x)(c_x{}^2 x^2) - (1 + k_y)(c_y{}^2 y^2)}} + \sum_{i=1}^{m} A_i x^{2i} + \sum_{i=1}^{m} B_i y^{2i}$$

in which c_x and c_y are the curvature of the surface in the direction of the X axis and Y axis, respectively, and k_x, k_y and the correction factor A_i and B_i are constants.

4. A beam-shaping optical element according to claim 3, in which the values of c_x and c_y are substantially different.

5. A beam-shaping optical element according to claim 3, in which A_i is non-zero for at least one value of i and B_j is non-zero for at least one value of j.

6. A beam-shaping optical element according to any one of claims 1 to 5, in which at least one of the entrance and exit surfaces has a shape for minimizing the wave front aberrations of a light beam from a radiation source having passed through the beam-shaping optical element.

7. A beam-shaping optical element according to any one of claims 1 to 6, wherein an elliptical cross-section of a beam supplied by a radiation source is converted into a substantially circular cross-section.

8. A beam-shaping optical element according to any one of claims 1 to 7, positioned between a semiconductor laser and an optical element for converting a beam from the semiconductor laser into a parallel, diverging or converging light beam.

9. A beam-shaping optical element according to any one of claims 1 to 8, wherein a distance from the emitting point of a semiconductor laser to the entrance surface of the element is smaller than a distance from the image of the emitting point formed by the beam-shaping optical element to the entrance surface and with the image located in the object space.

10. A beam-shaping optical element according to any one of claims 1 to 9, wherein the mathematical equation

$$(NA_{out}/2)\,(1/NA_{inx} + 1/NA_{iny}) < 1$$

is satisfied, where NA_{out} is a numerical aperture at the exit surface and NA_{inx} and NA_{iny} are numerical apertures at the entrance surface in the X-Z plane and Y-Z plane, respectively.

11. An optical pick-up system for scanning an optical recording medium and provided with a light source and an objective lens for converging a light beam from the light source on the recording medium, wherein a beam-shaping element according to one of the preceding claims is arranged in the optical path between the light source and the objective system.

12. An optical scanning device for scanning an optical recording medium and provided with an optical pick-up system according to claim 11, wherein the pick-up system includes a photo detector for converting light from the optical recording medium to an electric signal representing information stored on the record carrier, and the scanning device includes an error-correction circuit connected to the electric signal.

13. A method for designing a beam-shaping optical element in such a way that aberrations are minimized, the optical axis of the beam-shaping optical element coinciding with the Z-axis of a three-axis rectangular XYZ system of coordinates, at least one of the entrance surface and the exit surface of the beam-shaping optical element being represented by a mathematical equation comprising a term representing a non-rotationally symmetric aspherical profile and correction terms, each correction term being a function of either variable X or Y, at least one of the correction terms being a function of variable X and at least one of the correction terms being a function of variable Y, the method comprising the steps of:

-determining constraints including a vergence of the beam at the entrance surface and a vergence of the beam at the exit surface;

-obtaining a merit function for at least wave front aberration;

-obtaining a value for the merit function under the above constraints;

-determining whether or not the value of the merit function reaches a desired value; and

-adjusting at least one correction term to cause the merit function to approach the desired value.

14. A method for designing a beam-shaping optical element according to claim. 13, wherein the at least one of the entrance surface and the exit surface of the element is represented by the mathematical equation

$$Z = \frac{c_x x^2 + c_y y^2}{1+\sqrt{1-(1+k_x)(c_x^2 x^2)-(1+k_y)(c_y^2 y^2)}} + \sum_{i=1}^{m} A_i x^{2i} + \sum_{i=1}^{m} B_i y^{2i}$$

in which c_x and c_y are the curvature of the surface in the direction of the X axis and Y axis, respectively, and k_x, k_y and the correction factor A_i and B_i are constants.

15. A method for making a beam-shaping optical element comprising the step of designing the beam-shaping optical element according to claim 13 or 14, and the step of making the optical element according to the design.

16. A computer program for designing a beam-shaping optical element in such a way that aberrations are minimized, the optical axis of the beam-shaping optical element coinciding with the Z-axis of a three-axis rectangular XYZ system of coordinates, at least one of the entrance surface and the exit surface of the beam-shaping optical element being represented by a mathematical equation comprising a term representing a non-rotationally symmetric aspherical profile and correction terms, each correction term being a function of either variable X or Y, at least one of the correction terms being a function of variable X and at least one of the correction terms being a function of variable Y, the program having a computer perform the steps of:

-determining constraints including a vergence of the beam at the entrance surface and a vergence of the beam at the exit surface;

-obtaining a merit function for at least wave front aberration;

-obtaining a value for the merit function under the above constraints;

-determining whether or not the value of the merit function reaches a desired value; and

-adjusting at least one correction term to cause the merit function to approach the desired value.

17. A computer program for designing a beam-shaping optical element according to claim 16, wherein the at least one correction term comprising a function of variable X alone comprises a power of X, multiplied by a correction factor and the at least one correction term comprising a function of variable Y alone comprises a power of Y, multiplied by a correction factor.

18. A computer program for designing a beam-shaping optical element according to claim 16, wherein the at least one of the entrance surface and the exit surface of the element is represented by the equation

$$Z = \frac{c_x x^2 + c_y y^2}{1+\sqrt{1-(1+k_x)(c_x{}^2 x^2)-(1+k_y)(c_y{}^2 y^2)}} + \sum_{i=1}^{m} A_i x^{2i} + \sum_{i=1}^{m} B_i y^{2i}$$

in which c_x and c_y are the curvature of the surface in the direction of the X axis and Y axis, respectively, and k_x, k_y and the correction factor A_i and B_i are constants.

19. A computer program product contained in a tangible medium for operating with a computer in implementing a method as claimed in claim 13.